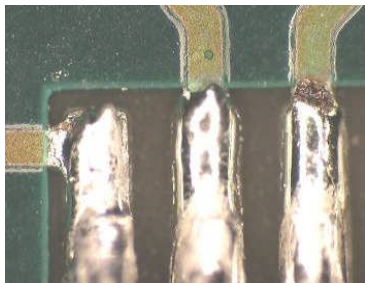


# NASA-DoD Lead-Free Electronics Project

April 2009



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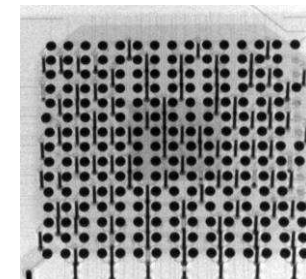
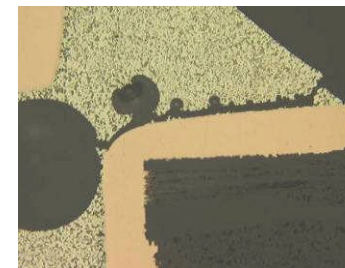
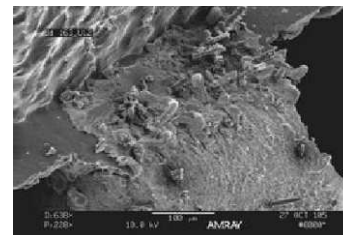
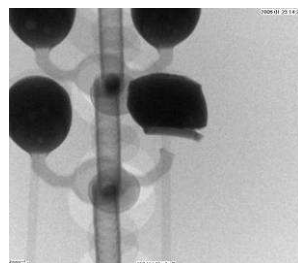
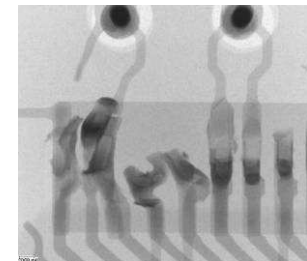
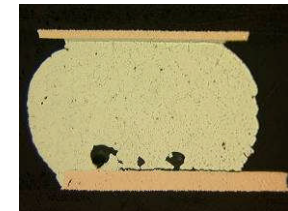
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Testing project will build on the results from the JCAA/JGPP LFS Project

The primary technical objective of this project is to undertake comprehensive testing to generate information on failure modes/criteria to better understand the reliability of:

Packages (e.g., Thin Small Outline Package [TSOP], Ball Grid Array [BGA], Plastic Dual In-line Package [PDIP]) assembled and reworked with lead-free alloys

Packages (e.g., TSOP, BGA, PDIP) assembled and reworked with mixed (lead/lead-free) alloys.

**Web Links:**

**NASA-DoD Lead-Free Electronics Project:**

**[http://www.teerm.nasa.gov/projects/NASA\\_DODLeadFreeElectronics\\_Proj2.html](http://www.teerm.nasa.gov/projects/NASA_DODLeadFreeElectronics_Proj2.html)**

**JCAA/JGPP Lead-Free Solder Project**

**[http://www.teerm.nasa.gov/projects/LeadFreeSolderTestingForHighReliability\\_Proj1.html](http://www.teerm.nasa.gov/projects/LeadFreeSolderTestingForHighReliability_Proj1.html)**

# Comparison of NASA-DoD LFE Project to predecessor JCAA/JG-PP LFS Project

## Similarities

- Virtually identical test vehicle
- Procedures identical for most tests
- Same facility for assembly
- SN100C being used for wave soldering

## Differences

- Test articles will be thermally aged after assembly
- Increased rework
- Increased solder mixing
- Mechanical shock test procedure
- Drop testing
- Immersion Ag surface finish for most test vehicles
  - Limited number will have ENIG
- SAC305 being used for reflow soldering
- SN100C being used for reflow soldering

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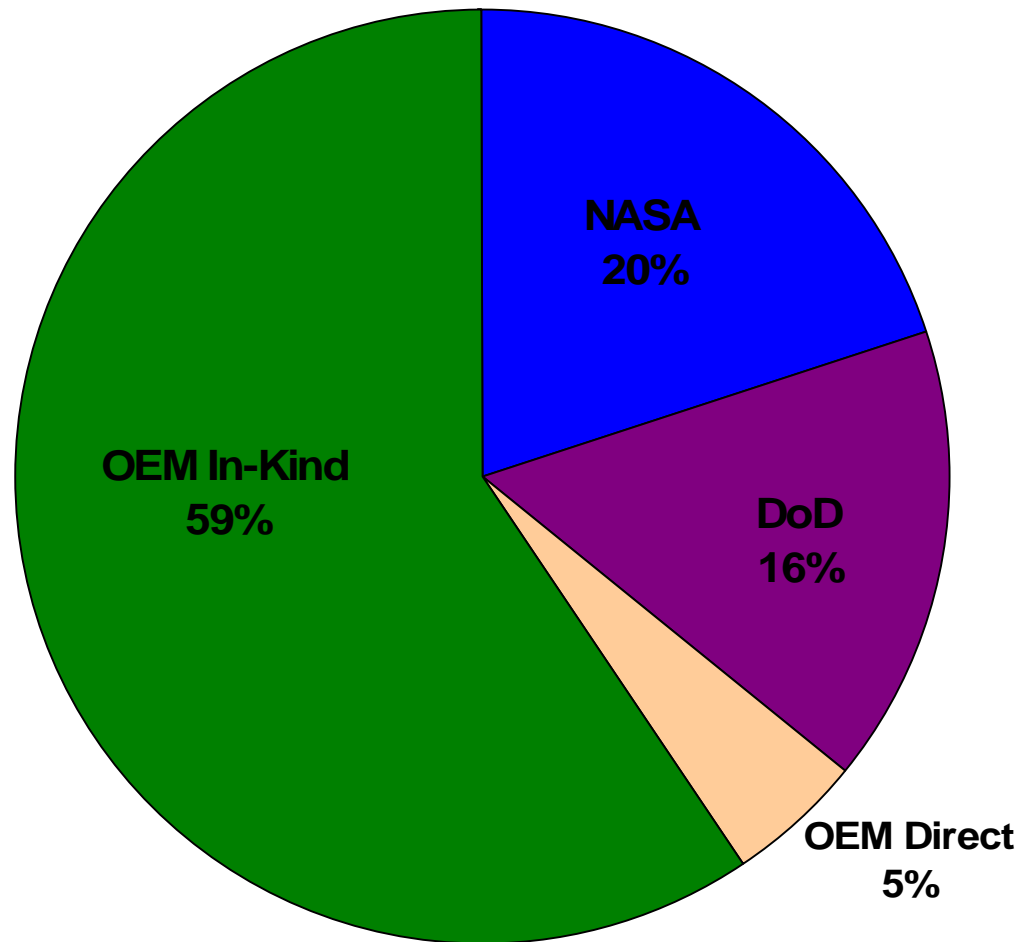
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# Joint Test Protocol Endorsement

Endorsement signifies agreement that the JTP contains performance and technical requirements applicable to specific applications within programs, and provides the consensus needed to move forward with testing.

- AIA (Aerospace Industries Association )
- Air Force - Electronic Engineer (WR-ALC/ENFM)
- Air Force - Director of Engineering (DOE) for the 312/326 Aeronautical Systems Wing (AESW); Wright-Patterson Air Force Base
- Army Research Lab
- Headquarters - Air Force Space Command
- NASA - NEPP Program
- NASA-MSFC - Packaging, EEE Parts & Electrical Manufacturing Branch Chief
- Naval Air Warfare Center, Aircraft Division
- MDA – PMP Program Lead
- NSWC Crane Division - 2M Project Manager
- NSWC Crane Division - 2M (Miniature/Microminiature) Electronics Technician
- NSWC Crane Division - Electronics Engineer, Testing: Printed Circuit Technologies Branch
- NSWC Crane Division - Materials Engineer; FA/MA Branch, Flight Systems Division
- BAE Systems - Principal Process Engineer
- BAE Systems - Vice President of Engineering for Electronics and Integrated Solutions
- Celestica - Director of Technology - IAD sector
- COM DEV - Director, Design Integrity
- General Dynamics - Design Assurance Engineering Manager
- Harris - Process Engineering Group Lead
- Lockheed Martin - Engineering Manager
- Nihon Superior - President of Nihon Superior
- Radiance Technologies, Inc. - AERI Program Manager
- Rockwell Collins - Director, Advanced Manufacturing Technology
- TT Apsco - Vice President and General Manager
- Willcor Inc. - Best Manufacturing Practices

# Contributions to the NASA-DoD Lead-Free Electronics Project ~\$1.8 Million



# Lead-Free Solder Alloys

- SAC305 (Sn3.0Ag0.5Cu)

- Surface mount assembly

This alloy was chosen for reflow soldering because this particular solder alloy has shown the most promise as a primary replacement for tin-lead solder. The team decided that they wanted to select at least one “general purpose” alloy to be evaluated and it was determined that the SnAgCu solder alloy would best serve this purpose.

- SN100C (Sn0.7Cu0.05Ni+Ge)

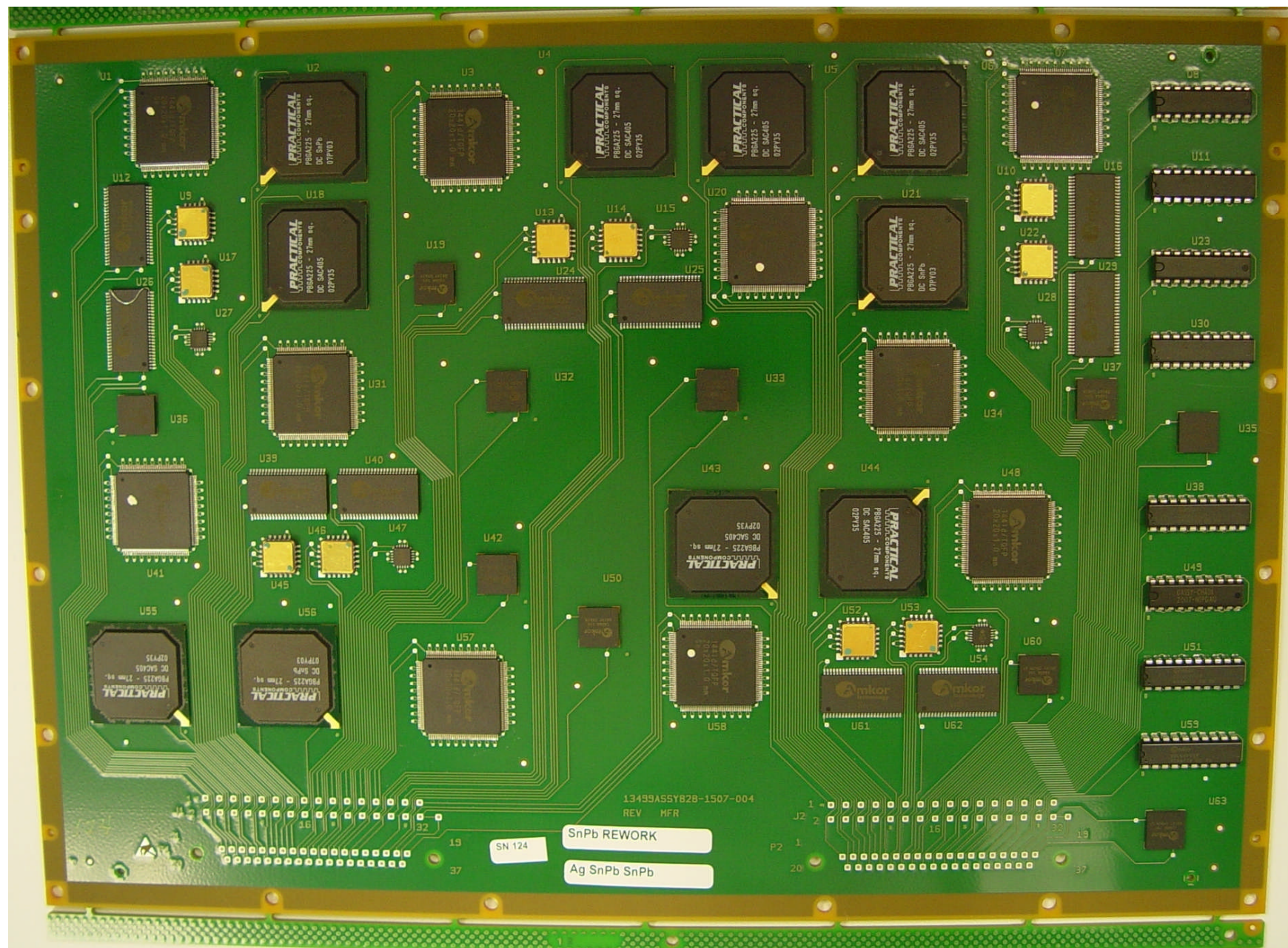
- Plated through hole

- Surface mount assembly

This alloy is commercially available and the general trend in industry has been switching to the nickel stabilized tin-copper alloy over standard tin-copper due to superior performance. In addition, this nickel-stabilized alloy does not require special solder pots and has shown no joint failures in specimens with over 4 years of service.



# 193 Test Vehicles Assembled





# Component Finish/Solder Combinations Example

SnPb Manufactured Test Vehicles				
Component	Component Finish	Reflow Solder	Wave Solder	Board Finish
BGA-225	SAC405	SnPb		Immersion Silver
BGA-225	SnPb	SnPb		
CLCC-20	SAC305	SnPb		
CLCC-20	SnPb	SnPb		
CSP-100	SAC105	SnPb		
CSP-100	SnPb	SnPb		
PDIP-20	NiPdAu		SnPb	
PDIP-20	Sn		SnPb	
QFN	Matte Sn	SnPb		
TQFP-144	Matte Sn	SnPb		
TQFP-144	SnPb Dip	SnPb		
TSOP-50	SnBi	SnPb		
TSOP-50	SnPb	SnPb		

## Profiles used during initial assembly

### Reflow Profile = SnPb

Preheat = ~ 120 seconds @140-183°C  
 Solder joint peak temperature = 225°C  
 Time above reflow = 60-90 sec  
 Ramp Rate = 2-3 °C/sec

### Wave Profile = SnPb

Solder Pot Temperature = 250°C  
 Preheat Board T = 101°C  
 Peak Temperature = 144°C  
 Speed: 110 cm/min

# Component Finish/Solder Combinations Example

Lead-Free Manufactured Test Vehicles							
Component	Component Finish	Set A			Set B		
		Reflow Solder	Wave Solder	Board Finish	Reflow Solder	Wave Solder	Board Finish
BGA-225	SnPb	SAC305		Immersion Silver ----- A limited Number of Boards will be Built with ENIG	SN100C		Immersion Silver
BGA-225	SAC405	SAC305			SN100C		
CLCC-20	SnPb	SAC305			SN100C		
CLCC-20	SAC305	SAC305			SN100C		
CSP-100	SnPb	SAC305			SN100C		
CSP-100	SAC105	SAC305			SN100C		
PDIP-20	NiPdAu		SN100C			SN100C	
PDIP-20	Sn		SN100C			SN100C	
QFN	Matte Sn	SAC305			SN100C		
TQFP-144	SnPb Dip	SAC305			SN100C		
TQFP-144	Matte Sn	SAC305			SN100C		
TSOP-50	SnPb	SAC305			SN100C		
TSOP-50	SnBi	SAC305			SN100C		

## Profiles used during initial assembly

### Reflow Profile = SAC305

Preheat = 60-120 seconds @150-190°C

Peak temperature target = 243°C

Reflow:~20 seconds above 230°C

~30-90 seconds above 220°C

### Wave Profile = SN100C

Solder Pot Temperature = 265°C

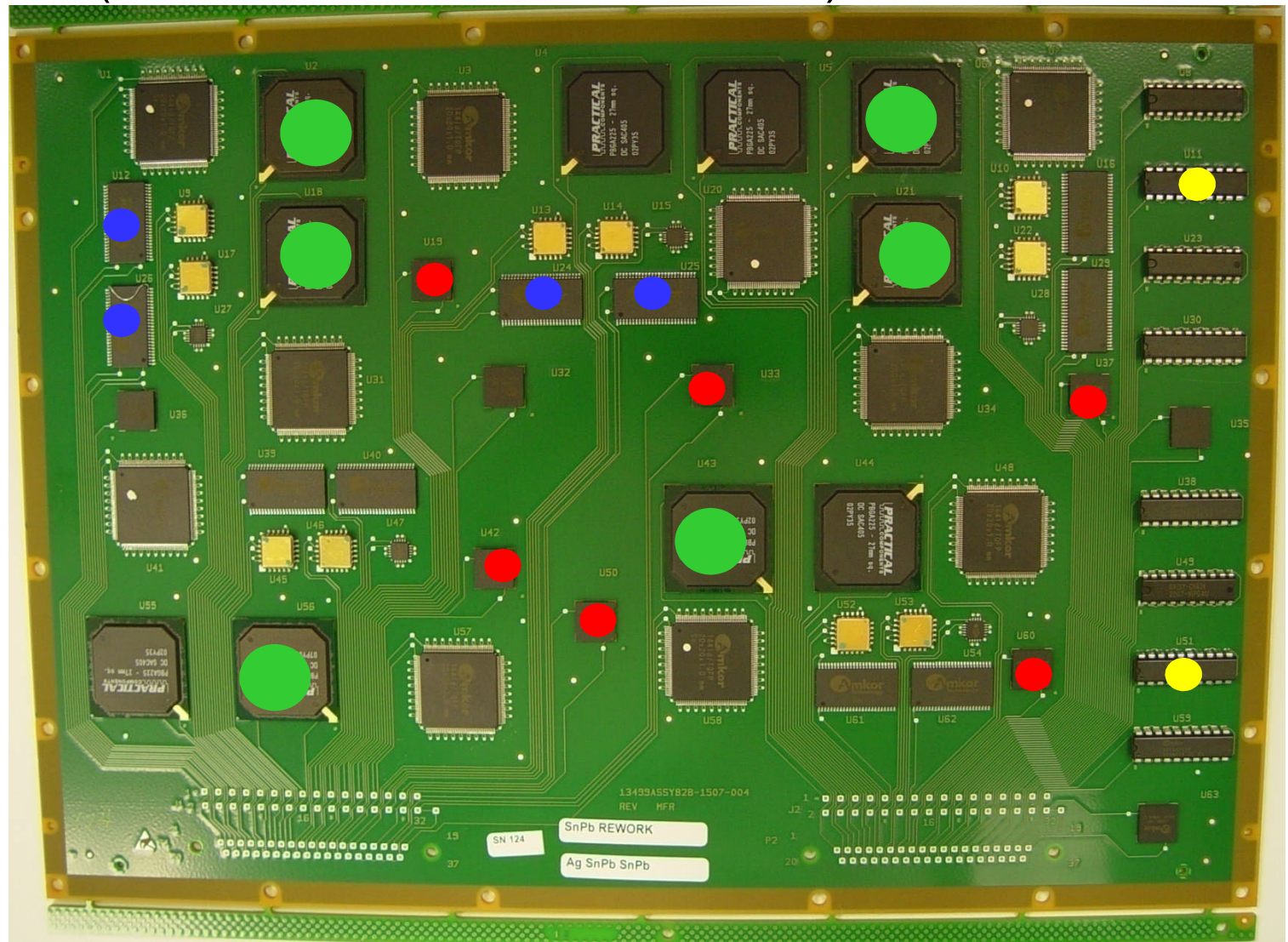
Preheat Board T = 134°C

Peak Temperature = 157°C

Speed: 90 cm/min

# 73 Test Vehicles Being Reworked (sub-set of the 193 assembled)

RefDes	Component
U18	BGA-225
U43	BGA-225
U06	BGA-225
U02	BGA-225
U21	BGA-225
U56	BGA-225
U33	CSP-100
U50	CSP-100
U19	CSP-100
U37	CSP-100
U42	CSP-100
U60	CSP-100
U11	PDIP-20
U51	PDIP-20
U12	TSOP-50
U25	TSOP-50
U24	TSOP-50
U26	TSOP-50



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# Component Finish/Solder Combinations Example

SnPb Rework Test Vehicles						
Component	Original Component Finish	Reflow Solder	Wave Solder	New Component Finish	Rework Solder	Board Finish
BGA-225	SAC405	SnPb				Immersion Silver ----- A limited Number of Boards will be Built with ENIG
BGA-225	SnPb	SnPb		SAC405	SnPb	
BGA-225	SnPb	SnPb		SnPb	Flux Only	
CLCC-20	SAC305	SnPb				
CSP-100	SAC105	SnPb				
CSP-100	SnPb	SnPb		SnPb	Flux Only	
CSP-100	SnPb	SnPb		SAC105	SnPb	
PDIP-20	NiPdAu		SnPb			
PDIP-20	Sn		SnPb			
PDIP-20	SnPb		SnPb	Sn	SnPb	
QFN	Matte Sn	SnPb				
TQFP-144	NiPdAu	SnPb				
TQFP-144	SnPb Dip	SnPb				
TSOP-50	Sn	SnPb				
TSOP-50	SnBi	SnPb				
TSOP-50	SnPb	SnPb		SnPb	SnPb	
TSOP-50	SnPb	SnPb		Sn	SnPb	

## Profiles used during initial assembly

### Reflow Profile = SAC305

Preheat = 60-120 seconds @150-190°C

Peak temperature target = 243°C

Reflow:~20 seconds above 230°C

~30-90 seconds above 220°C

### Wave Profile = SN100C

Solder Pot Temperature = 265°C

Preheat Board T = 134°C

Peak Temperature = 157°C

Speed: 90 cm/min



# Component Finish/Solder Combinations Example

Lead-Free Rework Test Vehicles						
Component	Component Finish	Reflow Solder	Wave Solder	New Component Finish	Rework Solder	Board Finish
BGA-225	SnPb	SAC305				Immersion Silver
BGA-225	SAC405	SAC305		SAC405	SnPb	
BGA-225	SAC405	SAC305		SAC405	Flux Only	
CLCC-20	SnPb	SAC305				
CSP-100	SnPb	SAC305				
CSP-100	SAC405	SAC305				
CSP-100	SAC105	SAC305		SAC105	Flux Only	
CSP-100	SAC105	SAC305		SAC105	SnPb	
PDIP-20	Sn		SN100C			
PDIP-20	Sn		SN100C	Sn	SN100C	
QFN	SnPb	SAC305				
TQFP-144	NiPdAu	SAC305				
TQFP-144	SAC 305 Dip	SAC305				
TSOP-50	SnBi	SAC305				
TSOP-50	SnPb	SAC305				
TSOP-50	Sn	SAC305		Sn	SnPb	
TSOP-50	SnBi	SAC305		SnBi	SAC305	

## Profiles used during initial assembly

### Reflow Profile = SAC305

Preheat = 60-120 seconds @150-190°C

Peak temperature target = 243°C

Reflow:~20 seconds above 230°C

~30-90 seconds above 220°C

### Wave Profile = SN100C

Solder Pot Temperature = 265°C

Preheat Board T = 134°C









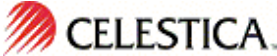
Peak Temperature = 157°C

Speed: 90 cm/min

# Testing Activities

Specific testing details can be found in the Joint Test Protocol (JTP)


<http://www.teerm.nasa.gov/reports.html>

Thermal Cycling: -20°C to +80°C 	Thermal Cycling: -55°C to +125°C 	Drop Testing 
Vibration 	Mechanical Shock 	Interconnect Stress Testing 
Combined Environments Testing 	Copper Dissolution  	

# NAVSEA Crane Rework Effort

- Build 30 test vehicles (sub-set of the 193 assembled)
  - Test vehicles will be built with Lead-Free solder and Lead-Free component finishes only = similar to Manufactured test vehicles for Mechanical Shock, Vibration and Drop Testing
  - Lead-Free alloys, SAC305 and SN100C
  - Rework will be done using only SnPb solder
  - Perform multiple pass rework 1 to 2 times on random Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components
  - Testing
    - Thermal Cycling -55°C to +125°C
    - Vibration Testing
    - Drop Testing

# Thermal Cycle -20/+80°C

Parameters	<ul style="list-style-type: none"><li>- -20 to +80°C</li><li>- Cycles: The project consortia will review the data and determine when the test is complete</li><li>- Decision point 10,000 cycles</li><li>- 5 to 10°C/minute ramp</li><li>- 30 minute high temperature dwell</li><li>- 10 minute low temperature dwell</li></ul> 				
Number of Test Vehicles Required					
Manufactured		Rework			
Mfg. SnPb	Mfg. LF	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF	
5	5	5	1	5	
Trials per Specimen		1			





# Phase 1 = JCAA/JGPP Lead Free Solder Project Test Results

- **27,135 thermal cycles**
  - All of the ceramic leadless chip carriers (CLCC's) and TSOP's had failed
  - Most of the BGA's had failed (SnPb solder/SnPb balls; SAC solder/SAC balls; SACB solder/SAC balls; and mixed technologies)
  - Most of the TQFP-144's had failed

# Combine Environments Testing

Parameters

-

-55°C to +125°C

-

Number of cycles ≥ 500

-

20°C/minute ramp

-

15 minute soak

-

Vibration for duration of thermal cycle

-

10 G<sub>rms</sub>, initial

-

Increase 5 Grms after every 50 cycles

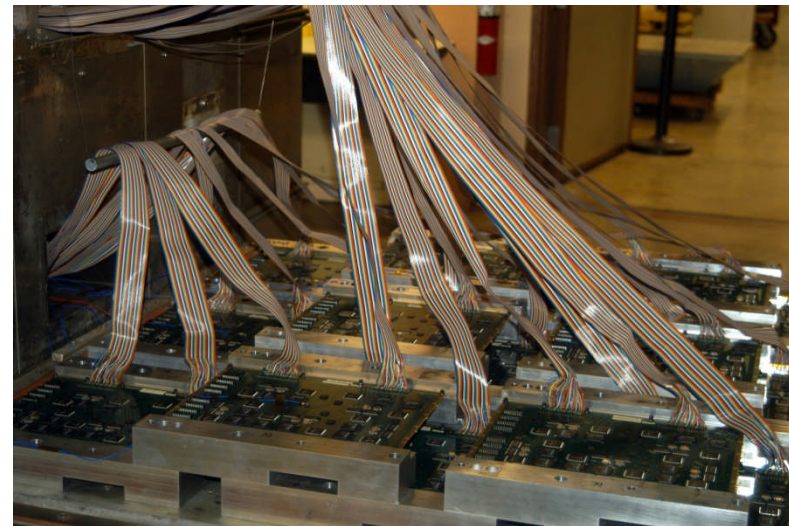
-

55 G<sub>rms</sub>, maximum

Number of Test Vehicles Required

Manufactured				Rework		
Mfg. SnPb	Mfg. LF	Mfg. LF SN100C	Mfg. LF ENIG	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	1	5	1	5
Trials per Specimens		1				

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# Status

- 500 cycles complete on 03/13/09
- Results
  - Only 14 of 150 CSPs have failed
  - Approximately 30% of components have failed
  - SnPb/SAC BGA-225s first component group to fail
- HALT chamber down 03/16 – 03/19
  - Repaired and ready for testing
- Test vehicles will continue combined environments testing, running at 55 grms
  - Will run 50 cycles and check status
- Testing re-start on 03/23/09
- Rework test vehicles are wired

# Failure Map After 500 Cycles

Part	MFG SnPb					MFG SnAgCu					MFG Sn100C					
	20	21	22	23	24	69	70	71	72	73	116	117	118	119	120	
U2	188			314	150			330				181	234	122	307	
U5	437				122			54							213	
U21																
U44								196						234		
U56					271			242				166		146		
U4	128	255	158	104	96		492			174		20	468	100	153	
U6	130	234	142	40	77					188		330		114		
U18	116	164	89	97	111			247		169		49	345	94		
U43	94	147	160	120	27			213		110		380		150	172	
U55	114	106	133	157	86		363	157		68	227	202	369	2		
U10		322				414			293	429			366			
U14	325									306	293	400	314	332		
U17	479		424			365	292		344	457		484	225	200	458	
U45	465		392		450	340			443	227		264	492	72	323	
U52	361	394				312			281	212			324			
U9	252	294	484			282	243	322	344	327		360	332	306		
U13	383		288		285	256	290	238	282	302		433	259			
U22		232	370		388	446	371	218			228			244	256	
U46	334		322			317	486		374	241			464	211		
U53	472		387		378	438	372	302		424	243			413	323	
U19								461								
U36														233		
U37		493													476	
U42																
U60																
U32	434			423									350			
U33					319											
U35		194			401											
U50	394	495														
U63					463									492		
U11																
U30																
U38													344			
U51																
U8																
U23													446			
U49																
U59													460			
U15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
U27																
U28																
U47																
U54																
U3													494	428		
U31														255		
U34		0														
U48																
U57		1												444		
U1														384		
U7					343							434				
U20																
U41														316		
U58																
U16		344		113	362			208	278			276	315	192	246	
U24													202	194	328	
U26									201			209	250	150	272	

U15 = QFN component missing an I/O trace and is dead – all test vehicles

## Test vehicles 20 – 24

- SnPb Manufactured Batch C
- SnPb Reflow and Wave solder
- SnPb profiles.

## Test vehicles 69 – 73

- LF Manufactured Batch E
- LF Reflow (SAC305) / Wave (SN100C)
- LF profiles

## Test vehicles 116 – 120

- LF Manufactured Batch G
- LF Reflow (SN100C) / Wave (SN100C)
- LF profiles

## Component Finish

BGA	SnPb	SAC405
CLCC	SnPb	SAC305
CSP	SnPb	SAC105
TQFP	SnPb	Matte Sn
TSOP	SnPb	SnBi



# Failure Map After 500 Cycles

## Test vehicles 20 – 24

- SnPb Manufactured Batch C
- SnPb Reflow and Wave solder
- SnPb profiles.

## Test vehicles 69 – 73

- LF Manufactured Batch E
- LF Reflow (SAC305) / Wave (SN100C)
- LF profiles

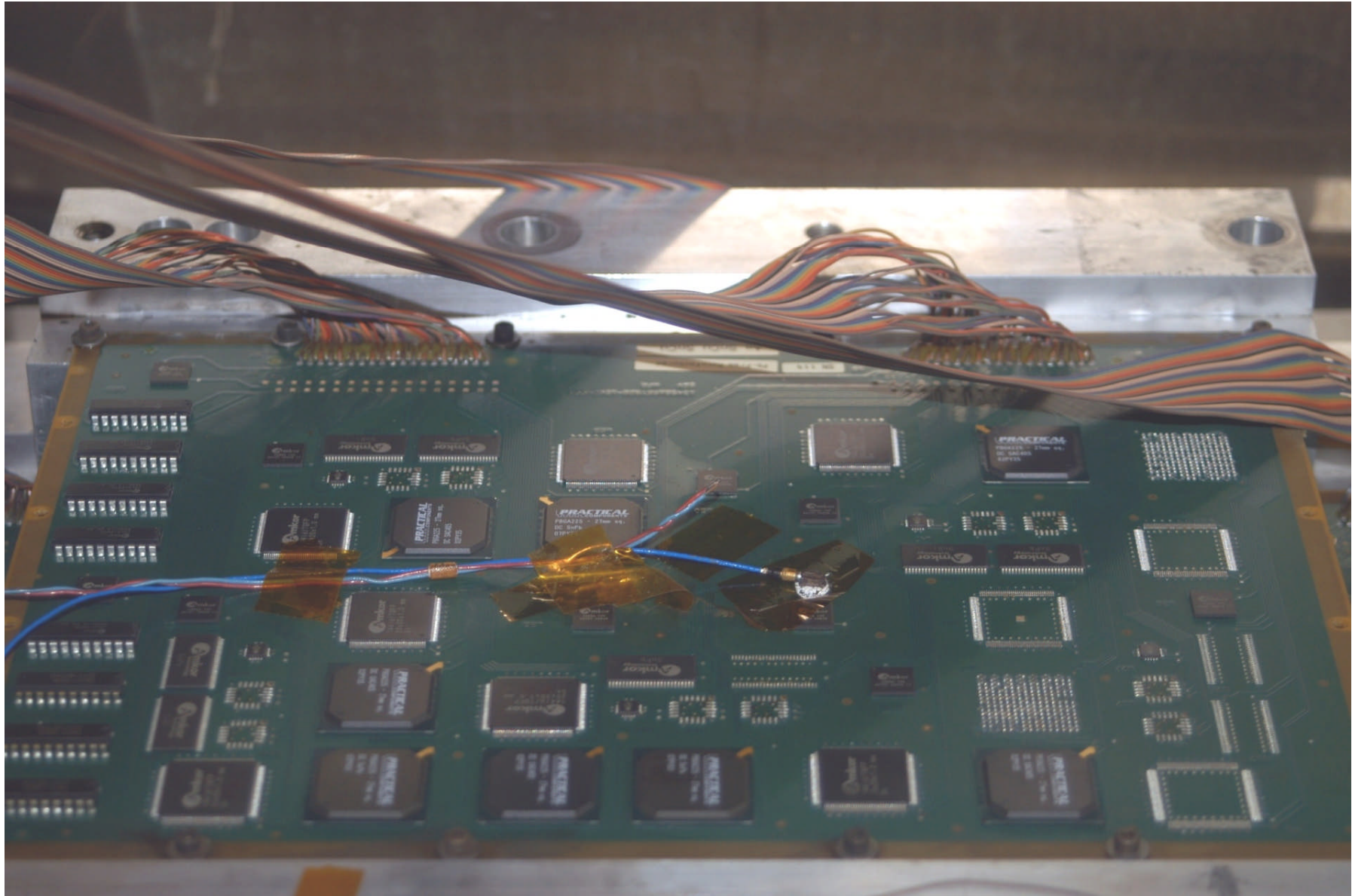
## Test vehicles 116 – 120

- LF Manufactured Batch G
- LF Reflow (SN100C) / Wave (SN100C)
- LF profiles

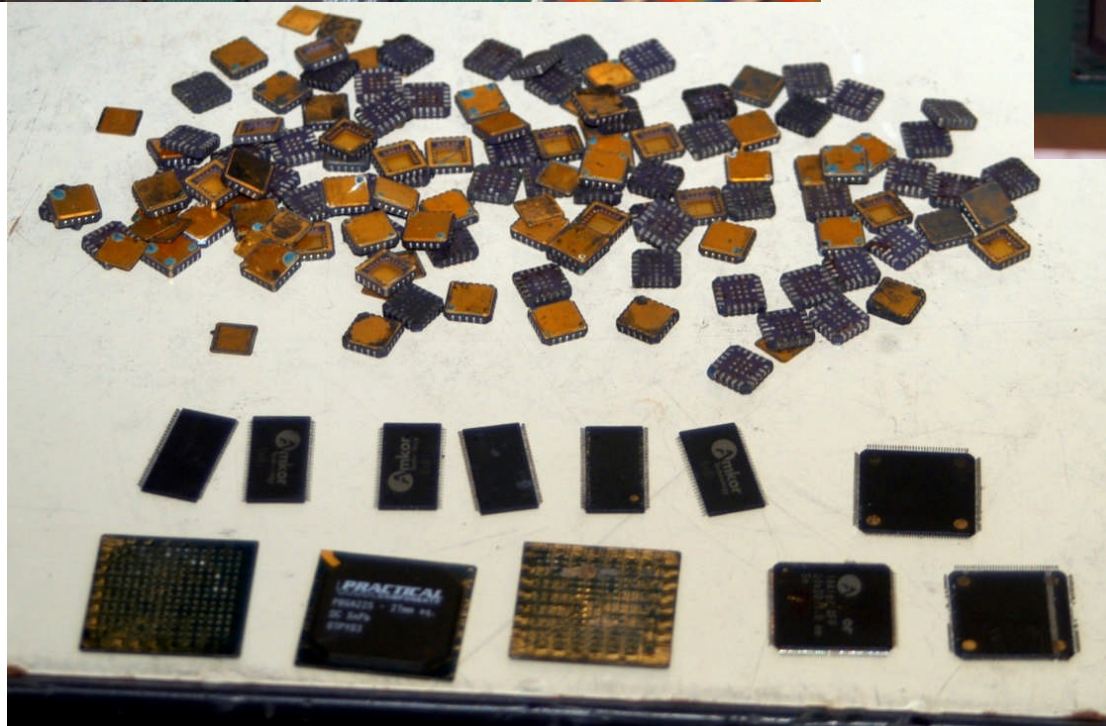
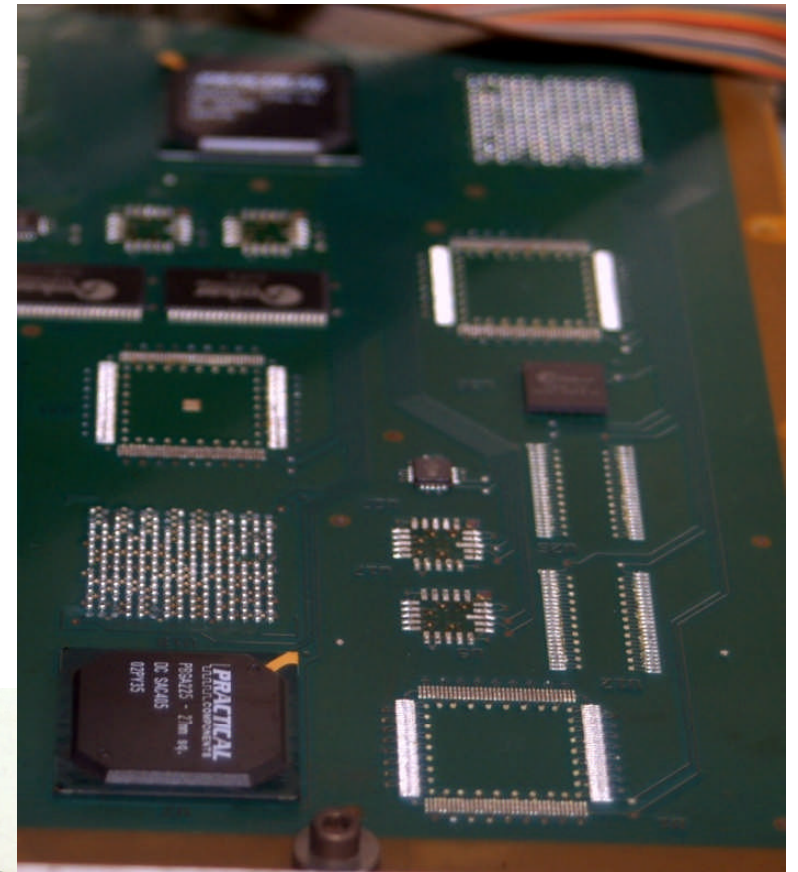
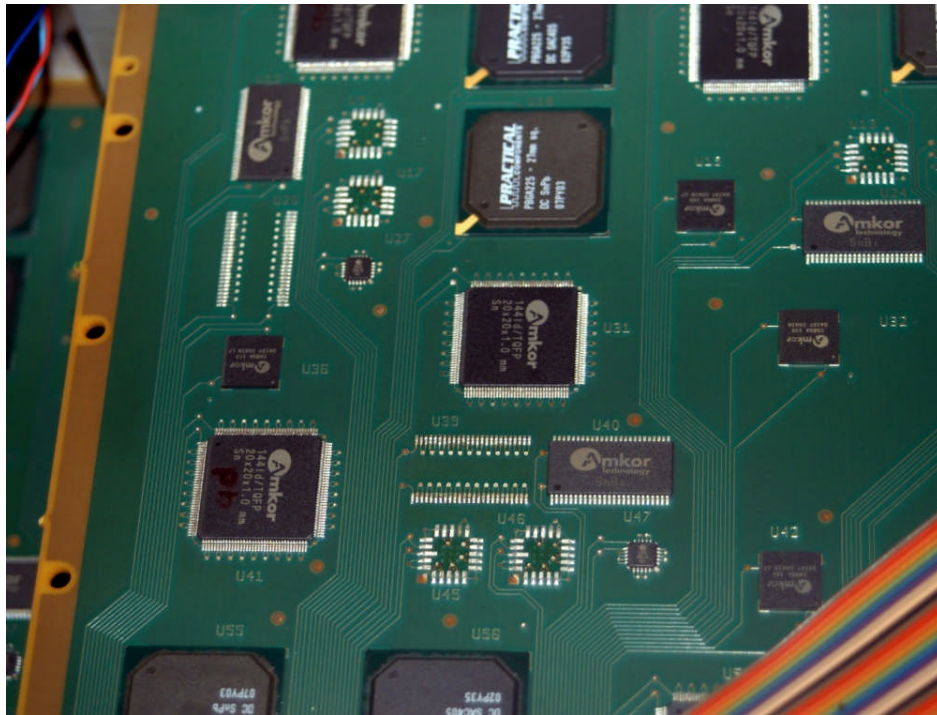
Part	MFG SnPb					MFG SnAgCu					MFG Sn100C							
	20	21	22	23	24	69	70	71	72	73	116	117	118	119	120			
U2	188			314	150			330				181	234	122	307			
U5	437				122			54							213			
U21																	BGA-225	
U44								196						234				
U56					271			242				166		146			SnPb	SAC405
U4	128	255	158	104	96		492			174		20	468	100	153			
U6	130	234	142	40	77					188		330		114				
U18	116	164	89	97	111			247		169		49	345	94			BGA-225	
U43	94	147	160	120	27			213		110		380		150	172			
U55	114	106	133	157	86		363	157		68	227	202	369	2				
U10		322				414			293	429			366					
U14	325									306	293	400	314	332				
U17	479		424			365	292		344	457		484	225	200	458		CLCC-20	
U45	465		392		450	340			443	227		264	492	72	323			
U52	361	394				312			281	212			324				SnPb	SAC305
U9	252	294	484			282	243	322	344	327		360	332	306				
U13	383		288		285	256	290	238	282	302		433	259					
U22		232	370		388	446	371	218			228			244	256		CLCC-20	
U46	334		322			317	486		374	241			464	211				
U53	472		387		378	438	372	302	424	243				413	323			
U19							461											
U36														233				
U37		493													476		CSP-100	
U42																		
U60																		
U32	434			423									350				SnPb	SAC105
U33					319													
U35		194			401												CSP-100	
U50	394	495																
U63					463										492			
U11																		
U30																	Sn PDIP-20	
U38													344					
U51																		
U8																		
U23													446				NiPdAu PDIP-20	
U49																		
U59													460					
U15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
U27																		
U28																	Matte Sn QFN-20	
U47																		
U54																		
U3													494	428				
U31														255				
U34		0															TQFP-144	
U48																		
U57		1												444			SnPb	Matte Sn
U1														384				
U7					343								434					
U20																	TQFP-144	
U41															316			
U58																		
U16		344		113	362			208	278			276	315	192	246			
U24													202	194	328			
U26									201			209	250	150	272		TSOP-50	

SnPb

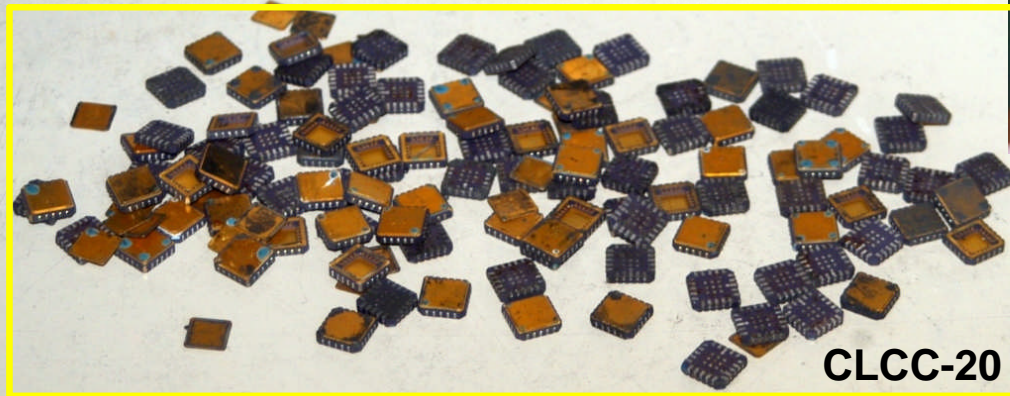
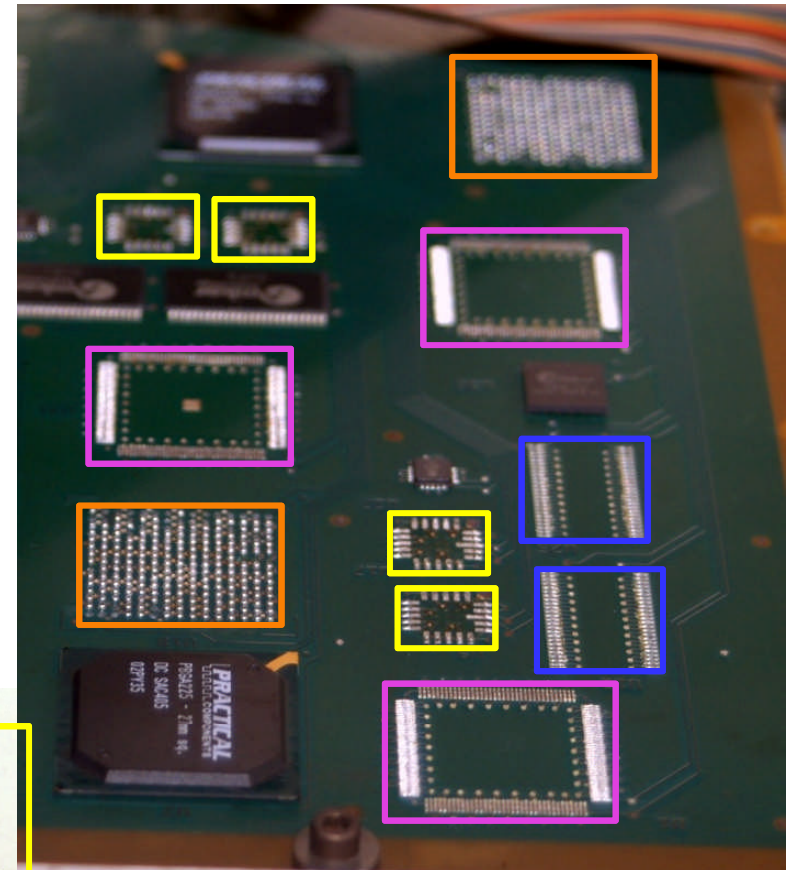
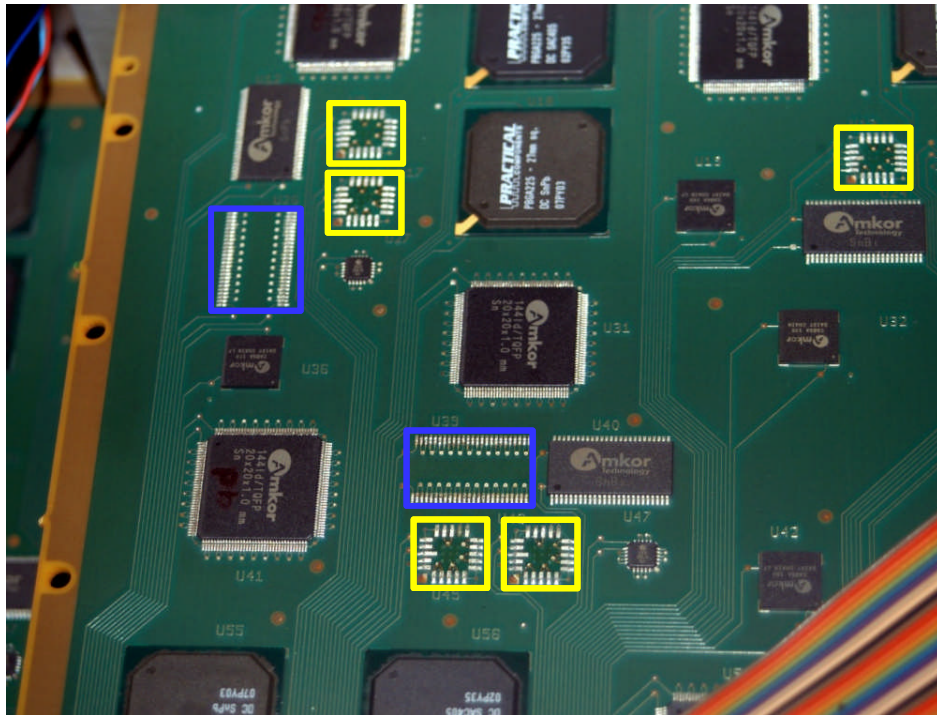
SnBi











CLCC-20

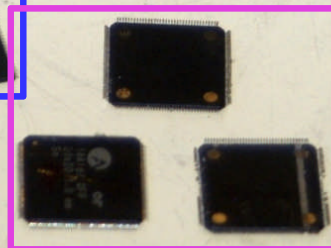
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BGA-225

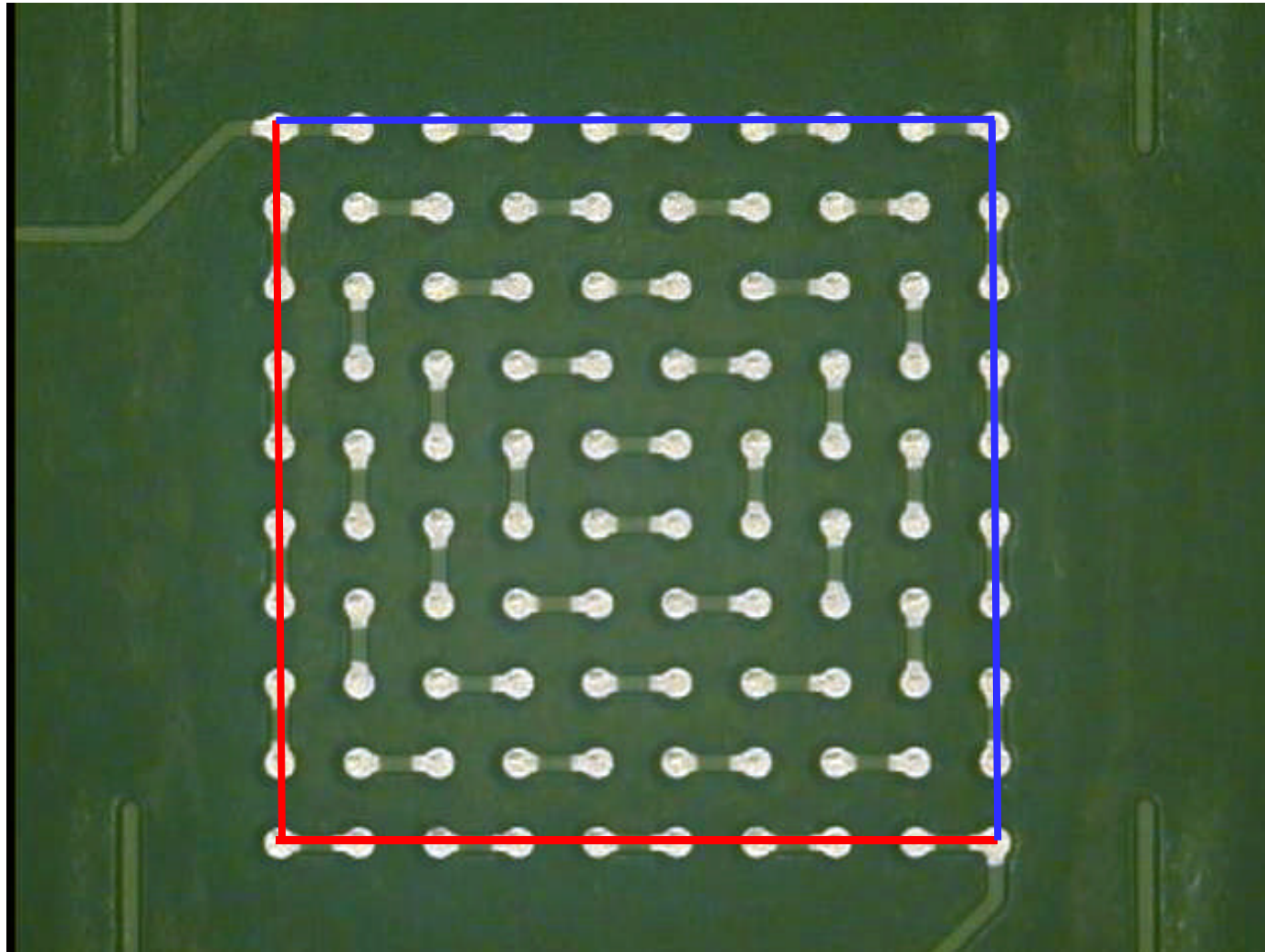


TQFP-144



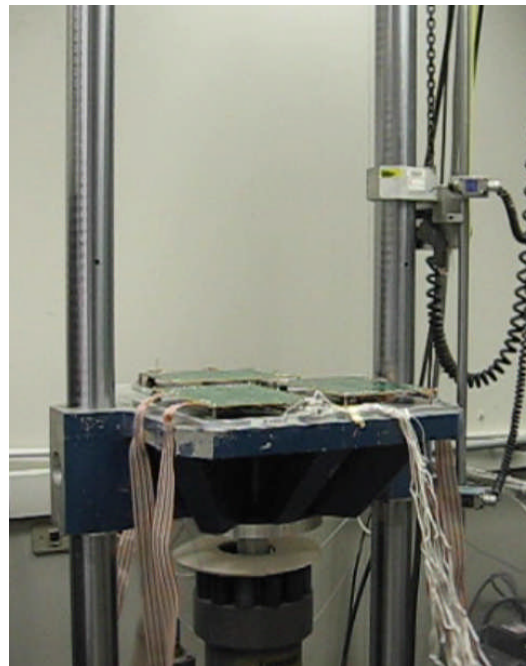


When reviewing the CSP data, please note that the CSP components on all test vehicles only have continuity in the outside solder balls.

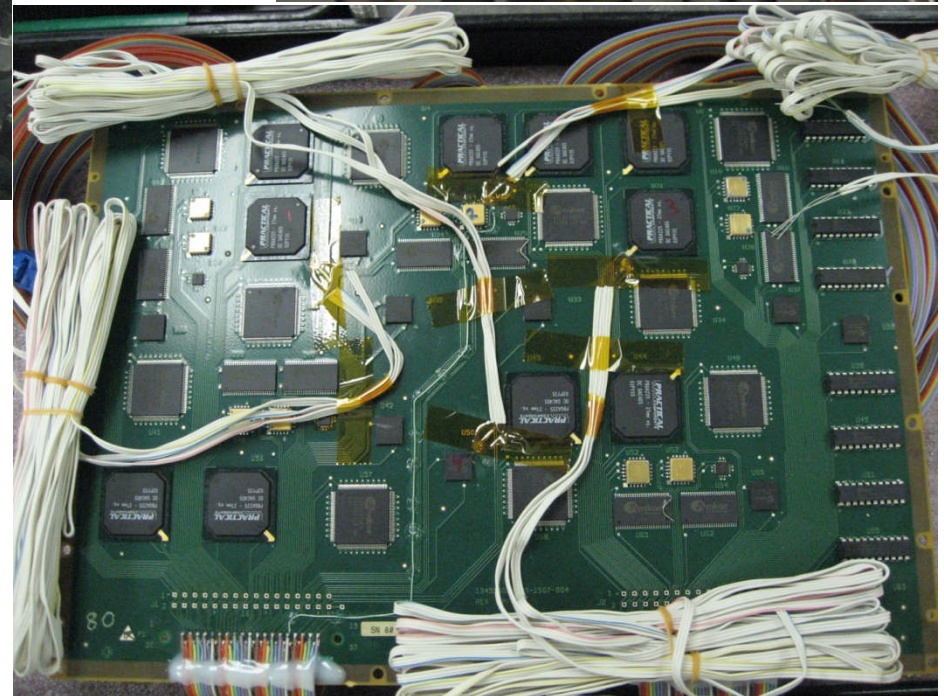
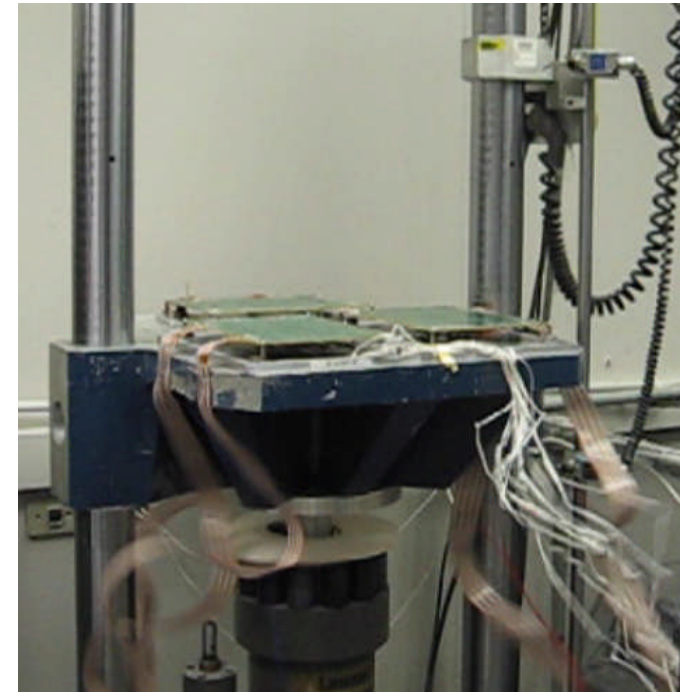
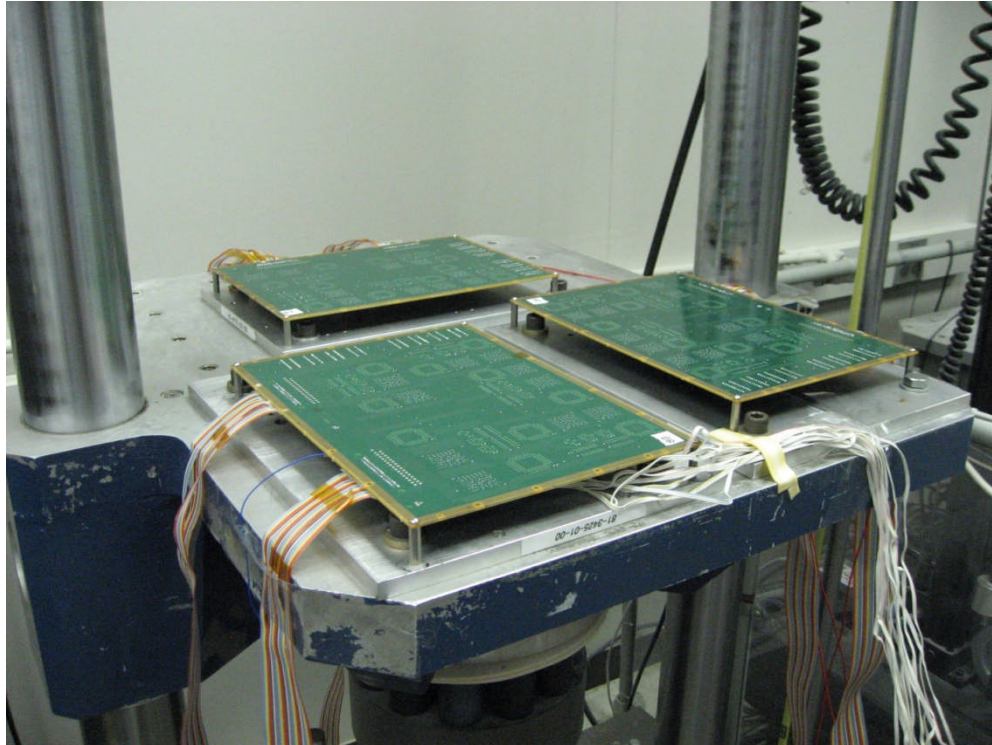


# Drop Testing

Parameters	<ul style="list-style-type: none"><li>- Shock testing will be conducted in the -Z direction</li><li>- 340Gpk input, 2ms pulse duration</li><li>- Test vehicles will be dropped until all monitored components fail or 10 drops have been completed</li></ul>			
Number of Test Vehicles Required				
Manufactured		Rework		
Mfg. SnPb	Mfg. LF	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	1	5
Trials per Specimen		A maximum of 10 drops		



# Drop Testing





# NAVSEA Crane Rework Effort - Drop Test Vehicles

- Perform multiple pass SnPb rework 1 to 2 times on random Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components

RefDes	Part	Number of Reworks					
		Drop Test Board (Lead-Free Manufactured Batch F)					
		SN80	SN82	SN84	SN85	SN86	SN87
U16	TSOP 50/SnBi	2	2	2	1	2	1
U24	TSOP 50/SnBi	0	0	0	0	0	0
U26	TSOP 50/SnBi	0	0	0	1	0	1
U40	TSOP 50/SnBi	1	1	1	2	1	2
U62	TSOP 50/SnBi	1	1	1	0	1	0
U12	TSOP 50/Sn	0	0	0	0	0	0
U25	TSOP 50/Sn	2	2	2	1	2	1
U29	TSOP 50/Sn	1	1	1	2	1	2
U39	TSOP 50/Sn	0	0	0	1	0	1
U61	TSOP 50/Sn	1	1	1	0	1	0
U9	CLCC-SAC305	2	2	2	1	2	1
U10	CLCC-SAC305	1	1	1	2	1	2
U13	CLCC-SAC305	0	0	0	0	0	0
U14	CLCC-SAC305	0	0	0	0	0	0
U17	CLCC-SAC305	2	2	2	1	2	1
U22	CLCC-SAC305	1	1	1	2	1	2
U45	CLCC-SAC305	0	0	0	1	0	1
U46	CLCC-SAC305	1	1	1	0	1	0
U52	CLCC-SAC305	0	0	0	1	0	1
U53	CLCC-SAC305	1	1	1	0	1	0
U1	TQFP-144/Sn	2	2	2	1	2	1
U3	TQFP-144/Sn	0	0	0	0	0	0
U7	TQFP-144/Sn	1	1	1	2	1	2
U20	TQFP-144/Sn	0	0	0	0	0	0
U31	TQFP-144/Sn	2	2	2	1	2	1
U34	TQFP-144/Sn	1	1	1	2	1	2
U41	TQFP-144/Sn	0	0	0	1	0	1
U48	TQFP-144/Sn	1	1	1	0	1	0
U57	TQFP-144/Sn	0	0	0	1	0	1
U58	TQFP-144/Sn	1	1	1	0	1	0
U08	PDIP-20/NiPdAu	1	1	1	2	1	2
U49	PDIP-20/NiPdAu	1	1	1	2	1	2
U23	PDIP-20/NiPdAu	1	1	1	0	1	0
U30	PDIP-20/Sn	0	0	0	1	0	1
U38	PDIP-20/Sn	1	1	1	0	1	0
U11	PDIP-20/Sn	1	2	2	1	2	1
U51	PDIP-20/Sn	1	2	2	1	2	1
U59	PDIP-20/Sn	0	1	1	0	1	0
U15	QFN/Sn	2	2	2	1	2	1
U27	QFN/Sn	1	1	1	2	1	2
U28	QFN/Sn	2	2	2	1	2	1
U47	QFN/Sn	0	0	0	1	0	1
U54	QFN/Sn	1	1	1	0	1	0

# NAVSEA Crane Rework Effort - Drop Test Vehicles

- The test vehicles are LF Manufactured Batch F
  - LF Reflow (SAC305) / Wave (SN100C)
  - LF profiles
  - All BGA components have SAC405 balls.
- Perform multiple pass SnPb rework 1 to 2 times on random Pb-free DIP, TQFP-144, TSOP-50, LCC and QFN components
- Test vehicles 80, 82, 87 were subjected to 10 drops at 340G and then 10 drops at 500G
- Test vehicles 84, 85, 86; 83, 81, 60 were subjected to 20 drops at 500G only



# NAVSEA Crane Rework Effort - Drop Test Vehicles

	PBGA 225								
	82	80	87	86	85	84	83	81	60
U18	12	17	15	10	2	6	9	17	0
U56	14	11	13	7	9	8	16	7	14
U55	19	11	19	7	6	3	9	6	15
U2	4	11	14	4	6	4	5	15	17
U4	10	11	6	3	2	4	2	9	6
U43	11	11	6	3	5	6	7	5	8
U21	8	8	10	5	5	3	5	4	5
U44	13	12	10	10	9	7	12	11	16
U5	5	7	5	4	3	2	5	4	4
U6	7	7	5	4	2	2	5	3	3

	CABGA 100								
	82	80	87	86	85	84	83	81	60
U32	0	0	0	0	0	0	0	0	0
U50	0	0	0	0	0	0	0	0	0
U33	0	0	0	0	0	0	0	0	0
U36	0	0	0	0	0	0	0	0	0
U19	0	0	0	0	0	0	0	0	0
U42	0	0	0	0	0	0	0	0	0
U37	0	0	0	0	0	0	0	0	0
U35	0	0	0	0	0	0	0	0	0
U63	0	0	0	0	0	0	0	0	0
U60	0	0	0	0	0	0	0	0	0

# NAVSEA Crane Rework Effort - Drop Test Vehicles

	CLCC 20								
	82	80	87	86	85	84	83	81	60
U9	0	0	0	0	0	0	0	0	0
U13	0	0	0	0	0	0	0	0	0
U14	0	0	0	0	0	3	0	0	0
U17	0	0	0	0	0	0	0	0	0
U45	0	0	0	0	0	0	0	0	0
U46	0	0	0	0	0	0	0	0	0
U22	0	0	0	0	0	0	0	0	0
U52	0	0	0	0	0	0	0	0	0
U53	0	0	0	0	0	0	0	0	0
U10	0	0	0	0	0	0	0	0	0

0 Rework

	QFN 20								
	82	80	87	86	85	84	83	81	60
U27	0	0	0	0	0	0	0	0	0
U15	0	0	0	18	0	0	0	0	0
U47	0	0	0	0	0	0	0	0	0
U54	0	0	0	0	0	0	0	0	0
U28	0	0	0	0	0	0	0	0	0

2x Rework

	PDIP 20								
	82	80	87	86	85	84	83	81	60
U11	0	0	0	0	0	0	0	0	0
U30	0	0	0	0	0	0	0	0	0
U38	0	0	0	0	0	0	0	0	0
U49	0	0	0	0	0	0	0	0	0
U51	0	0	0	0	0	0	0	0	0
U59	0	0	0	0	0	0	0	0	0
U8	0	0	0	0	17	0	0	0	0
U23	0	0	0	0	0	0	0	0	0

2x Rework

Number of Drops To Failure


# NAVSEA Crane Rework Effort - Drop Test Vehicles

	TQFP 144								
	82	80	87	86	85	84	83	81	60
U1	0	0	0	0	0	0	0	0	0
U41	0	0	0	0	0	0	0	0	0
U3	0	0	0	0	0	0	0	0	0
U57	0	0	0	0	7	0	0	0	0
U58	0	0	0	0	0	0	0	0	0
U31	0	0	0	0	0	0	0	0	0
U20	0	0	0	0	0	0	0	0	0
U48	0	0	0	0	0	0	0	0	0
U7	0	0	0	0	0	0	0	0	0
U34	0	0	0	0	0	0	0	0	0

1x Rework

	TSOP 50								
	82	80	87	86	85	84	83	81	60
U26	0	0	0	0	0	0	0	0	0
U39	0	0	0	0	0	0	0	0	0
U40	0	0	0	0	0	0	0	0	0
U25	0	0	0	0	0	0	0	0	0
U12	0	0	0	0	0	0	0	0	0
U24	0	0	0	0	0	0	0	0	0
U61	0	0	0	0	0	0	0	0	0
U16	0	0	0	0	0	0	0	0	0
U62	0	0	0	0	0	0	0	0	0
U29	0	0	0	0	0	0	0	0	0

# Thermal Cycle -55/+125°C


Parameters	<ul style="list-style-type: none"><li>- -55 to +125°C</li><li>- Cycles: The project consortia will review the data and determine when the test is complete</li><li>- Decision point at 2,000 and 4,000 cycles</li><li>- 5 to 10°C/minute ramp</li><li>- 30 minute high temperature dwell</li><li>- 10 minute low temperature dwell</li></ul>					
						
Number of Test Vehicles Required						
Manufactured				Rework		
Mfg. SnPb	Mfg. LF	Mfg. LF SN100C	Mfg. LF ENIG	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	1	5	1	5
Trials per Specimen		1				

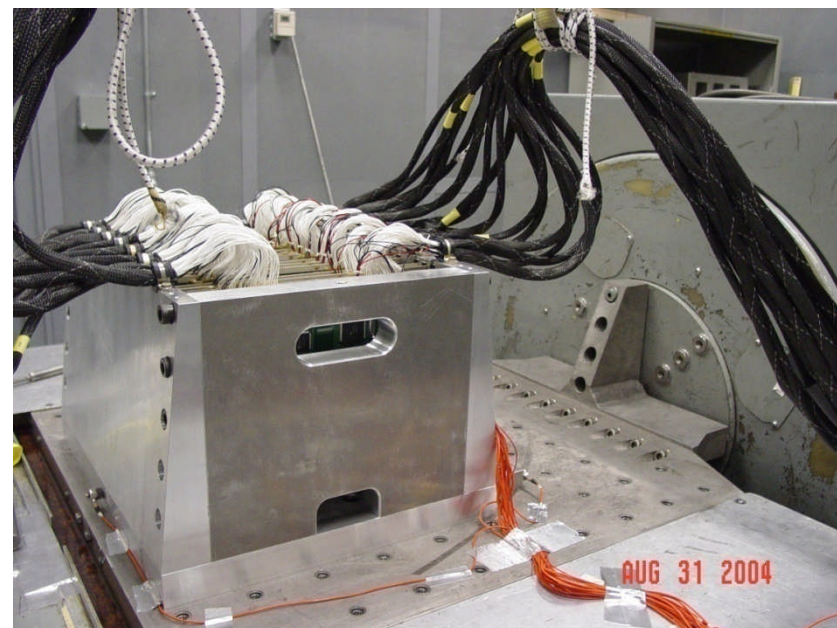
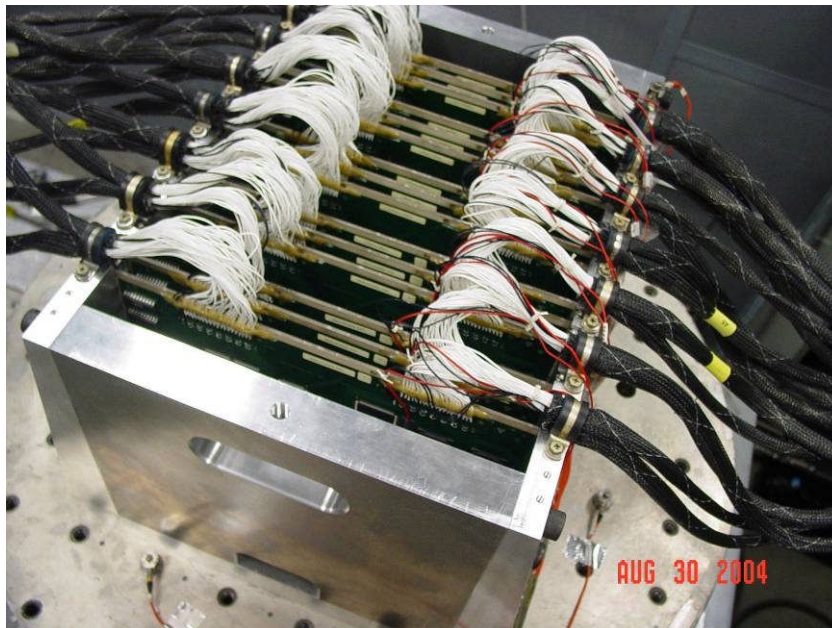
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# Vibration

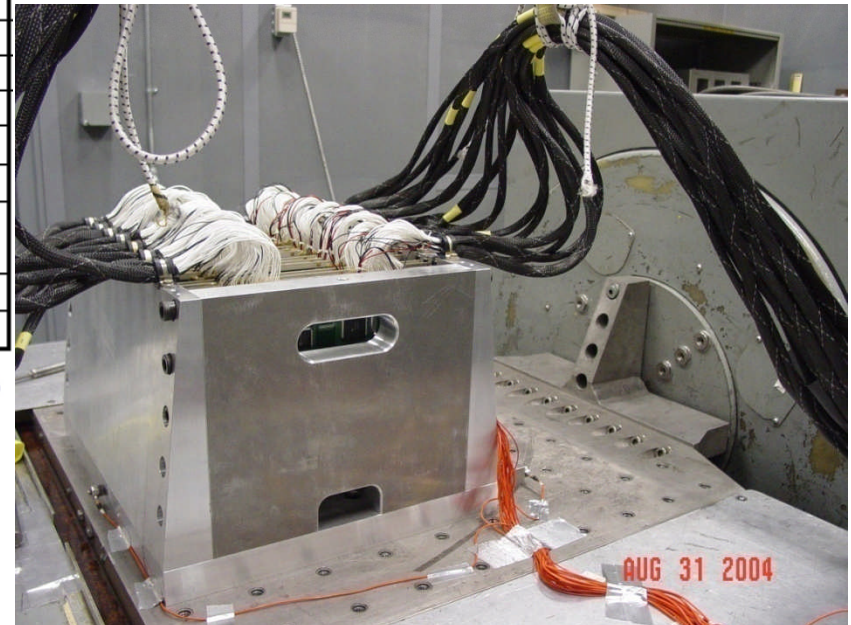
Parameters	- Start at 8.0 g <sub>rms</sub> then step up in 2 g <sub>rms</sub> increments in the axis perpendicular to the plane of the test vehicles until the 20.0 g <sub>rms</sub> level is completed. Vibrate for 1 hour at each test level. Finish with 1 hour at 28.0 g <sub>rms</sub> .					
<div></div>						
Number of Test Vehicles Required						
Manufactured				Rework		
Mfg. SnPb	Mfg. LF	Mfg. LF ENIG	Mfg. LF SN100C	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	1	5	5	1	5
Trials per Specimen			1			





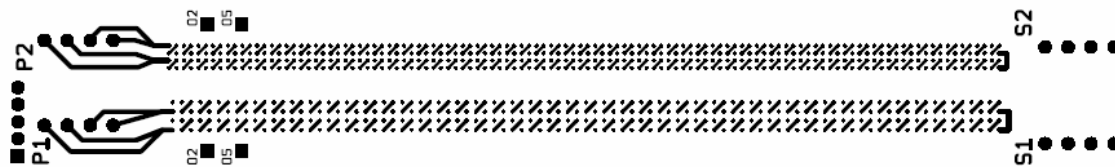
# Mechanical Shock

Parameters	The shock transients will be applied perpendicular to the plane of the board and will be increased after every 100 shocks (i.e., a step stress test). Frequency range is 40 to 1000 Hz. SRS damping: 5%			
	Test Shock Response Spectra	Amplitude (G's)	Te (msec)	Shocks per Level
	Modified Functional Test for Flight Equipment (Level 1)	20	<30	100
	Modified Functional Test for Ground Equipment (Level 2)	40	<30	100
	Modified Crash Hazard Test for Ground Equipment (Level 3)	75	<30	100
	Level 4	100	<30	100
	Level 5	200	<30	100
	Level 6	300	<30	100
	Level 7	500	<30	100
	Level 8	700	<30	100
Number of Test Vehicles Required				
Manufactured		Rework		
Mfg. SnPb	Mfg. LF	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	1	5
Trials per Specimen		1		



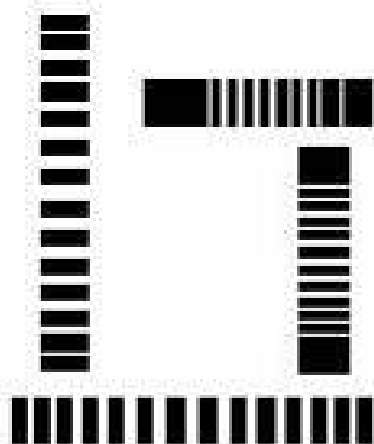
# Interconnect Stress Test (IST)

- Accelerates thermal cycling testing by heating a specifically designed test coupon to 150°C (higher temperatures in specific applications in exactly 3 minutes followed by cooling to ambient in approximately two minutes.
- Assembly and rework simulation is achieved by subjecting the coupon to heating to 230°C (260°C for lead-free applications) in three minutes followed by cooling to ambient in approximately 2 minutes.
  - Three thermal cycles simulate assembly
  - Six thermal cycles simulate assembly and rework

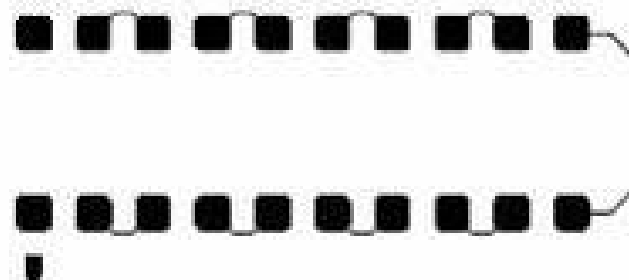


# Copper Dissolution

Parameters	<ul style="list-style-type: none"><li>▪Mini-wave soldering versus manual soldering</li><li>▪Number of component removals: 1X versus 3X</li><li>▪PDIPS on break off coupon and QFP pad pattern</li><li>▪Metallographic Analysis:<ul style="list-style-type: none"><li>▪As fabricated copper thickness</li><li>▪As assembled copper thickness</li><li>▪As reworked copper thickness</li></ul></li></ul>				
Number of Test Vehicles Break off Coupons Required					
Manufactured			Rework		
Mfg. SnPb	Mfg. LF	Mfg. LF SN100C	Rwk. SnPb	Rwk. SnPb ENIG	Rwk. LF
5	5	5	5	1	5



U64



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# NASA-DoD Lead-Free Electronics Project

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## Web Links:

- **NASA-DoD Lead-Free Electronics Project:**

[http://www.teerm.nasa.gov/projects/NASA\\_DODLeadFreeElectronics\\_Proj2.html](http://www.teerm.nasa.gov/projects/NASA_DODLeadFreeElectronics_Proj2.html)

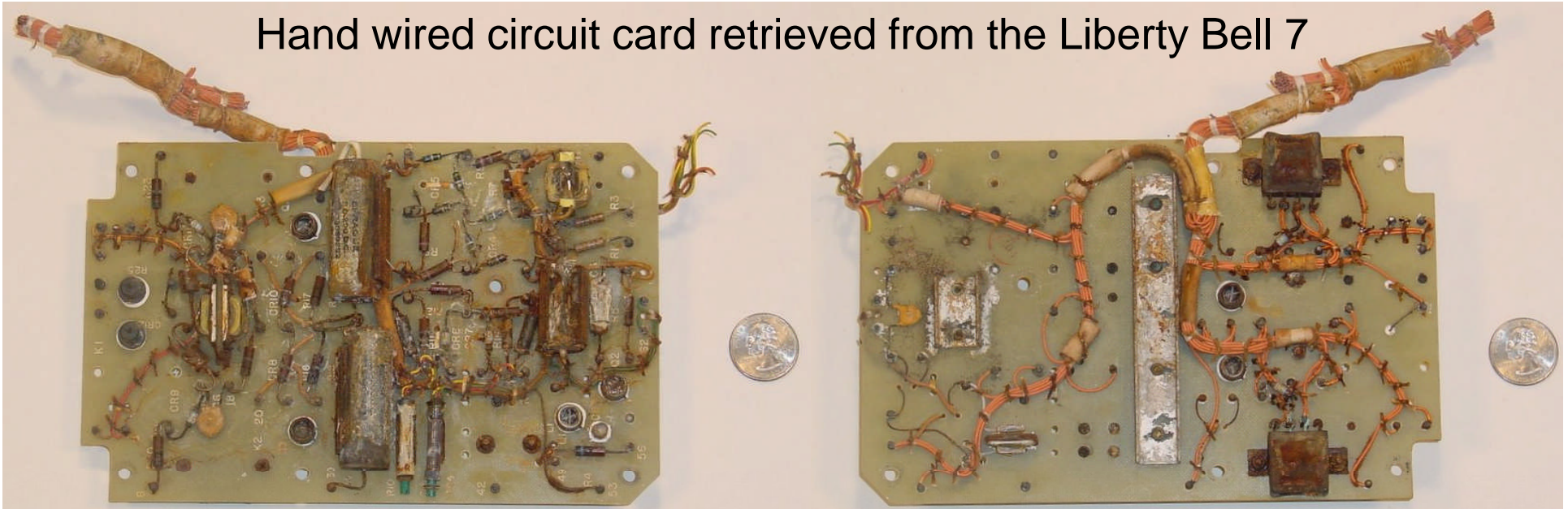
- **JCAA/JGPP Lead-Free Solder Testing for High Reliability:**

[http://www.teerm.nasa.gov/projects/LeadFreeSolderTestingForHighReliability\\_Proj1.html](http://www.teerm.nasa.gov/projects/LeadFreeSolderTestingForHighReliability_Proj1.html)



# Questions

Hand wired circuit card retrieved from the Liberty Bell 7



(<http://apollotribute.blogspot.com/2005/11/liberty-bell-7-circuit-card.html>)



The Liberty Bell 7 was pulled from a depth of 15,000 feet -- 3,000 feet deeper than the Titanic

